Iatrochemistry and the evaluation of mineral waters in France, 1600-1770

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> To imagine, examine, and observe with the eyes of a lynx
> The water that springs from bitumen, and leaps
> From the raging fires in the sulphurous deep;
> To recognise salts, to discover their contraries,
> And to spy their varieties—such are the deeds
> Of the sons of Phoebus and the friends of Aesclepius[i]

> Of all remedies known to medicine, both ancient and modern, none have been more successful through the ages than mineral waters, especially against chronic illness. The members of this Academy...have since their establishment been particularly concerned to discover the principles [*principes*] by which these waters have their effects [*effets*], so that a better knowledge of these principles will enable us to more reliably identify the diseases against which they can be usefully deployed.[ii]

The early modern belief in the therapeutic value of mineral springs has excited much interest among historians of medicine and chemistry, and rightly so. Historians of medicine have long observed that mineral waters were an essential item in the repertoire of many early modern physicians. Patients flocked to new bathing facilities that sprung up around Europe—Spa in Germany, Epsom and Tunbridge and Bath in England, Vichy and Forges and Bourbon-l'Archambault in France, and many others. Those who were too poor or too ill to travel to the source were served by a network of suppliers of bottled water that emerged in the seventeenth century and flourished in the eighteenth.[iii] In the same period, mineral waters drew the attention of chemists attached to new scientific institutions such as the Royal Society of London and the Parisian Royal Academy of Science. The consequences for chemistry were

considerable. Analyses of mineral waters contributed to the development of colour indicators, the articulation of a new theory of salts, and the rejection of the Aristotelian ideas that air is a single substance and that water can be transformed into earth.[iv] Chemists entered the medical marketplace by making artificial waters that (they claimed) had the same composition, and therefore the same effects on the body, as the natural waters from which they were derived as purifications or imitations.[v] In short, mineral waters seem to be a salutary instance of the early modern entanglement of chemists and physicians, and of science and medicine more generally.

But there is a blemish on this rosy picture of interaction and collaboration. The blemish concerns the *evaluation* of mineral waters, and it is especially apparent in the historiography of French mineral waters. On the one hand, it is said of seventeenth-century physicians that they evaluated mineral waters by examining their effects on the body and not by studying their composition. As Laurence Brockliss put it, "guesses might be made from [waters'] taste and smell, but essentially their composition was known from their effects."[vi] On the other hand, historians who have studied the chemical analyses of mineral waters at the Paris Academy of Science have had much to say about the consequences of these analyses for chemical theory and little to say about their consequences for medical practice. It seems that only physicians were seriously interested in assessing the medical virtues of mineral waters, and that only academic chemists were seriously interested in identifying the components of mineral waters.

The main aim in this paper is to show that this division is only apparent. Physicians and chemists shared an interest in, not an indifference to, the use of composition as a guide to the efficacy of mineral waters. Physicians used a range of physical and chemical tests to identify the components of mineral waters, and they used their identifications to demonstrate, predict, and promote the medical virtues of these waters. Conversely, chemists at the Paris

Academy of Sciences were serious about using their analyses of particular springs to shed light on the medical virtues of those springs. Their analyses had implications for medical practice by way of the reports they published in Academy's *Histoire* and *Mémoires*, the books they published on materia medica, the lectures they gave to medical students, the advice they gave to the king and his legal institutions, and the advice they gave to their own patients.

This paper also sheds light on the impact of iatrochemistry on early modern medical practice. By iatrochemistry I mean the practice of using the materials, procedures, theories and phenomena of chemistry to prepare cures and to understand their effect on sick bodies. Iatrochemistry flourished in early modern Europe in the wake of Philippus Aureolus Theophrastus Bombastus von Hohenheim (1493-1451), also known as Paracelsus, and Jean Baptiste van Helmont (1579-1644).[vii] References to mineral waters are not uncommon in the literature on early modern iatrochemistry. In an important article published in 1962, Allen Debus showed that Italian physicians had developed an impressive array of tests of mineral waters even before the spread of Paracelsus' ideas.[viii] By the middle of the sixteenth century, these tests included not only ancient techniques involving oak galls and evaporation, and Medieval innovations such as distillation, but also newer tests such as studying the size of the crystals in the residue, casting the residue on a hot iron, and dissolving the mineral water in acid prior to distillation. Paracelsus, van Helmont and their followers adopted these tests and added new ones. Iatrochemists were attracted to mineral waters as a clear example of an effective mineral remedy and as a proving ground for chemical theories about the formation of minerals in the earth and the causes of disorder in the human body.

What role did these ideas and techniques play in the practice of ordinary physicians? It is generally agreed that the Paracelsian enthusiasm for mineral remedies was partly responsible for the *general* increase in the therapeutic use of mineral springs in this period.[ix] But little is known about the effect of iatrochemistry on the evaluation of *particular* springs.

In particular, little is known about the effect that the increasingly sophisticated chemical tests had on these piecemeal evaluations. Bold claims have been made about the role of chemistry in legitimising new or existing spas. Christopher Hamlin goes so far as to say that "the vast proportion of scientific activity on mineral waters was undertaken to promote one spa or denigrate another."[x] However, as Hamlin himself observes, there was no direct route from analysis to evaluation. The analysis might fail to identify the substances it was supposed to identify, or the mineral water might contain substances that no known test could identify. Even if all substances in the water were correctly identified, further argument was needed to justify a judgement about the medical value of the water, since physicians disagreed about the effect that substances had on the body when taken individually. Even when they agreed on that question, they disagreed about how (if at all) the analyst could reason from the effects of substances taken individually to the effects of those substances taken in combination. Even if all these problems were solved, the chemists' conclusion might conflict with the observed effects of mineral waters on sick bodies, in which case there was an argument to be had about the relative merits of laboratory experiments and clinical experience. Considerations such as these lead Hamlin to the conclusion that chemistry had little effect on the legitimation of mineral waters before the advent of pneumatic chemistry in the second half of the eighteenth century.[xi]

This conclusion is probably unduly pessimistic, to judge from Noel Coley's study of seventeenth-century English physicians. Coley describes a debate about the Scarborough spring carried out in the 1660s between two physicians with practices in York. Both physicians appealed to chemical tests to argue for the presence of a particular set of minerals in the Scarborough spring.[xii] Clearly these physicians took chemical tests seriously. Even here, however, it is not obvious from Coley's account whether they used these tests as a guide to the medical virtues of the waters. Indeed, Coley implies that the debate had more to do

with the evaluation of the skills of the two physicians than it did with the evaluation of the spring.[xiii] The result is that we are still in the dark about the role that iatrochemistry played in the evaluation of particular English springs before the middle of the eighteenth century. Matters are even more obscure in the French case, since there is no French equivalent of Debus' study of English tests or of Coley's study of the use of these tests by English physicians.

The present paper is organised around a series of printed texts that illustrate the role of composition and iatrochemistry in the evaluation of particular springs. Section 1 introduces French writings on mineral waters and considers an early and important example of the genre, a treatise by Jean Banc first published in 1603. Banc was no chemist, but a close reading of his treatise shows that he frequently appealed to composition as a guide to the medical efficacy of particular springs. Section 2 considers three conservative physicians—Jean Aubrey, Jean de Combe, and Isaac Cattier—who had reservations about the chemical analysis of mineral waters but whose scepticism was by no means absolute. Sections 3 compares and contrasts two Paracelsians, one who worked on the margins of the medical establishment (Henry de Rochas) and one who worked within it (Pierre le Givre). Both applied chemistry to mineral waters, but neither abandoned appeals to clinical experience, and the more radical of the two (Rochas) made *greater* use of clinical experience than the other. Section 4 shows that academic research on mineral waters was noteworthy for its sheer quantity and for its close ties to medical practice. The conclusion sums up the two main themes of the paper: the widespread interest in using composition alongside clinical experience to evaluate mineral waters; and the complex evolution of the role that iatrochemistry played in these evaluations.

1. Composition without chemistry: Jean Banc (1603)

The best guide to the voluminous literature on mineral waters in early modern France is an annotated bibliography published by the Société Royale de médecine in the 1780s. The guide was the work of the physician Joseph-Barthélemy-François Carrère. It ran to nearly 500 pages and contained 898 items dating from early in the sixteenth century to 1770s. Carrère's annotations, brief and partial though they are, give us a rough indication of the importance of composition in the evaluation of mineral waters. On a list of works containing general methods of analysing mineral waters, Carrère cited four works published in France before 1700; all of these mentioned the components or "*principes*" of waters, and only one (by Samuel Duclos) emanated from the Paris Academy of Science. [xiv] Carrère's bibliographies of individual springs tell a similar story. In a sample of six springs, we find that Carrère cited a total of 34 texts published before 1700, none of which emanated from the Academy, and more than two-thirds of which (25) mentioned composition.[xv] We may infer that composition played a significant role in these texts.

To characterise this role, we need to look more closely at some of the texts on Carrère's bibliography. A good place to start is Jean Banc's *La mémoire renouvellée des merveilles des eaux naturelles*, first published in 1603.[xvi] Banc had a degree in medicine from the University of Montpellier and a flourishing practice in the town of Moulins.[xvii] He deserves our attention as one of only two seventeenth-century French authors who appeared on Carrère's list of "enumerations of mineral waters of France."[xviii] His treatise was still being read at the Academy of Sciences early in the eighteenth century, over a century after its first publication.[xix] Now, it is true that Banc's tests of the identity of the components of mineral waters were elementary compared to those that the Italian physician Gabriele Falloppio had written down half a century earlier.[xx] But Banc's treatise contains much discussion of the

composition of mineral waters, much evidence of Banc's own efforts to discover their composition, and many examples of Banc using these discoveries to substantiate his advice about the medical use of particular springs.

Banc devoted a chapter early in the treatise to the most common components of mineral waters. He explained that bituminous waters can be identified by their oily surface layer, the sulphur-like smell of their deposits, and the bitter taste of the residues they leave when evaporated. Banc gave similar recipes for identifying iron, vitriol, and nitre; later in the volume, when he discussed particular French springs, he did the same for alum, sulphur and bronze. [xxi] He included distillation as well as evaporation in his chapter on the identification of the components of waters, though he did not refer to any distillations or evaporations that he carried out himself for the purpose of making these identifications.[xxii] Some of Banc's tests demanded a firm hand or lively eye. In the town of Martres he opened rocks with a hammer to reveal their bitumen cores. At the springs of Vicleconte, he covered a well with a lid made of stone and cement, and he found that the waters penetrated this obstacle to a depth of nearly two feet; he also observed iron marcassites in the vicinity of this well.[xxiii] These are not isolated examples. Banc invoked one or more of his tests in his descriptions of *most* of the 17 warm sources that he surveyed in the third book in his volume.[xxiv]

The aim of these tests was not merely to explain the known powers of the waters that Banc reviewed. Explanation was one of his aims, but he also used the tests to decide whether or not a given source was worth adopting as a cure. His approach may be illustrated by his description of one of the cold springs at Vichy. According to Banc, the health benefits of this spring were unknown until he "diligently tested" them and found that they tasted just like the waters of Pougues, a source that had been used with great success against the paralysis of Madame de la Vauguion, the choleric of the Countess of Lude, and on Henry III himself.[xxv] Since Vichy water has the same taste as Pougues water, Banc reasoned, it probably has the

same components, and therefore the same effects on the body. On this evidence he prescribed the new source to several of his patients, and he presented their cases histories as "proof of [the] merit" of the new spring.[xxvi] Clinical experience was the ultimate test of the waters of Pougues, but their taste convinced Banc that they were worth taking seriously. This reading of Banc is corroborated by the fact that he recommended several springs without referring to any past cures. For example, he had not yet treated any patients with the waters of Clermont waters, so he was unable to "recognise their properties by way of experience." He was also wary of slander, "which is more often levelled against physicians in Auvergne than anywhere else in the world." He nevertheless declared that these waters would "produce excellent results against disease." Banc thereby staked his reputation on the bituminous taste and rust-coloured residue of the waters of Clermont.[xxvii] Seventeenth-century physicians did not need to perform complicated chemical analyses in order to reason from the composition of mineral waters to their medical effects.

2. Conservative chemistry: Jean Aubery, Jean de Combe, and Isaac Cattier (1604-1650)

Nor did they need to have radical views about the nature and value of chemical remedies. Consider Jean Aubery, a physician to the royal family whose study of the Bourbon waters appeared in 1604.[xxviii] According to Carrère, Aubery's was the second French treatise on these waters and the first since 1584. Aubery is also noteworthy for the fact that many passages from his book were copied verbatim by Jean de Combe, whose treatise on the waters of Greaux appeared in 1645 and stands as the first work published in France on Carrère's list of methods for analysing mineral waters.[xxix] Aubery and Combe took a thoroughly traditional view of the study of mineral waters. In particular, they had serious reservations about what

they called the "spagyric" approach to the study of the composition of mineral waters.[xxx] "Spagyria" was a term coined by Paracelsus. By 1600 his followers were using it to refer to the separation and re-combination of substances by means of laboratory operations such as evaporation, distillation, and dissolution.[xxxi] Paracelsus and his followers held that the art of spagyria was the key to transforming natural substances, including toxic ones, into pure and potent remedies. Aubery and Combe objected to the "*Paracelsistes*" on the dual grounds that chemical techniques are no more reliable than the unaided senses, and that natural mixtures are more perfect than artificial ones.[xxxii] Both of these objections had consequences for the evaluation of mineral waters. The reliability of the senses meant that the organs of taste and smell were just as effective as dissolution and distillation in identifying the components of mineral waters. And the intimate union of the components of natural springs meant they were more than the sum of their parts—they had effects on the body that none of their components had when taken separately. These super-added effects could only be known by observing the effect of the water on patients.[xxxiii]

These reservations were significant, but they did not amount to a blanket ban on inferences from the composition of mineral waters to their medical virtues. Though they argued for the reliability of the senses, Aubery and Combe did not argue that chemical tests are *less* reliable than the senses. On the contrary, they claimed that distillation is a necessary supplement to colour, odour and taste, and they instructed their readers on how to distil a mineral water and examine its residue.[xxxiv] Though they argued that *some* properties of mineral waters can only be detected by their effects on the body, they did not extend this rule to *all* properties. They believed that chemical tests could reliably identify the *strongest* components in the waters, and that such tests could to furnish sound advice about the medical use of those waters.[xxxv]

The writings of another conservative physician, Isaac Cattier, illustrate the role of

chemical knowledge in *disputes* about the therapeutic value of particular springs. Cattier was a Médecin ordinaire du Roi and graduate of the Montpellier Faculty of Medicine.[xxxvi] In 1650 he published a treatise on the waters of Bourbon in which he argued against the common practice of prescribing those waters against diseases caused by excessive heat. The standard objection to this practice was that all the known components of the Bourbon waters were hot and dry. The standard response was that mixtures can have medical effects that their components, taken separately, do not. Like Combe and Aubery before him, Cattier replied that mixtures were not entirely independent of their components. Although mixtures can have qualities that their components do not have, they cannot have qualities that are the *opposite* of the qualities of their *strongest* components. Salt, pepper, cloves, and hot herbs will never make a refreshing stock; likewise, sulphur, bitumen, nitre, salt and alum will never make a refreshing mineral water.[xxxvii] The esoteric question of the relationship between mixtures and their components was a crucial part of Cattier's argument against the use of Bourbon waters as a refreshing medicine.

Cattier engaged even more closely with chemistry in a dispute about the merits of the waters of Provins. In this case his opponent was Pierre le Givre, a physician at Provins who had maintained that the waters there contain no vitriol. In a letter to Givre, Cattier aligned himself with physicians who "judge the composition [of mineral waters] only by the effects they produce on the body."[xxxviii] Yet when we look closely at the details of Cattier's arguments, we find that they were no less chemical than Givre's. Consider the question of whether vitriol can be extracted from iron. One of Givre's critics, a certain Dr. Rainsant, had argued that it can, and hence that the Provins spring must contain vitriol if, as everyone agreed, it contained iron.[xxxix] Givre had countered that chemists had only extracted vitriol from *dissolved* iron, and that the vitriol came from the solvent and not from the iron itself. Cattier's contribution to this debate was not to deny that composition is relevant to medical

practice, or that chemistry is relevant to composition. Instead he discussed the colour and quantity of the vitriol that chemists had extracted from dissolved iron. He concluded that Rainsant was right: the vitriol in the chemists' experiments had come from the iron not the solvent, and it followed that the Provins spring contained vitriol.[xl] Cattier made a similar intervention in a debate about the ability of vitriol to convert iron into copper. Rather than ignoring Givre's experiments on this conversion, Cattier re-interpreted them in such a way as to support his conclusion that Provins water contains vitriol.[xli] Cattier was no Paracelsian, but he was willing to appeal to composition, and to the theories and experiments of chemistry, in disputes about the medical value of particular springs.

3. Paracelsian chemistry: Henry de Rochas and Pierre le Givre (1634-1667)

This is not to deny that Paracelsians were unusually fond of studying mineral waters by chemical means. Pierre le Givre was one such Paracelsian; Henry de Rochas was another. Both men studied mineral waters against the background of the broader debate in the French medical community about the value of chemical remedies. In 1634, when Rochas' treatise on mineral waters first appeared, the debate was at its height.[xlii] The conservative physicians at the Paris Faculty of Medicine were under threat from several quarters, including irregular physicians who peddled chemical remedies and published heady chemical cosmologies.[xliii] Rochas was one of these irregulars. He did not have a medical degree; instead he had been schooled in "*la medicine spagyrique*" by artisans in the mines that his father oversaw as Général des mines de Provence. Like other "*spagyristes*", Rochas converted sulphur into tablets and liquids and sold them as cures. He maintained that artificial waters are purer and more potent than natural ones, and easier to adapt to the needs of individual patients. He

described how to extract salt, sulphur and mercury from any substance; he argued for the existence of a "universal spirit" that continually replenishes mineral springs; and he published *La physique reformee* (1638), a rich brew of chemistry, astrology, nosology, and biblical hermeneutics.[xliv]

Whereas Rochas was a precocious outsider, Givre was a member of a reformed medical establishment. The increased openness of the physicians at the Paris Faculty was marked by their 1665 decision to endorse the most controversial of the new chemical remedies, the internal use of antimony.[xlv] Givre's two main treatises on mineral waters appeared on either side of this event, in 1653 and 1667.[xlvi] In the latter treatise he argued for the importance of "*la chymie*" in medicine, and in doing so he quoted from the writings of Paracelsus and poured scorn on the minority of physicians who continued to doubt the efficacy of chemical remedies: "they speak of what they do not know, like blind men about colours."[xlvii] The resemblance to Rochas ends there, however. Unlike Rochas, Givre was closely associated with the Paris Faculty of Medicine. He studied there for at least two years, dedicated his two treatises to members of the Faculty, and included an endorsement by two other members of the Faculty in his 1657 treatise.[xlviii] Givre did not develop a chemical cosmology on the scale of Rochas', and although he used artificial waters to study the composition of natural ones, he discouraged the use of artificial waters as remedies.[xlix] Whereas Rochas used his treatises to promote his pills and artificial waters, Givre used them to attract patients to the mineral spring at Provins, where he established a medical practice in the late 1640s.[l] Givre's arrival in Provins coincided with the renovation of the spa facilities there[li], and he sought in his treatises to "manifest and broadcast" the "good effects" of the "miraculous waters" in the town.[lii]

Rochas was more radical than Givre, but it was Givre who made the more extensive use of chemistry to evaluate mineral waters. For Rochas, analytical techniques such as

distillation and evaporation were *unnecessary* for the evaluation of the waters that interested him the most, namely artificial ones. He did not need to analyse these waters; he knew what their components were, because it was he who had put them there. Rochas' radicalism also meant that chemical analysis was *insufficient* for the evaluation of both artificial and natural waters. Traditional physicians could reason from the composition of waters to their effects because they could rely on medical authorities to tell them which components would cure which diseases. For example, Combe's knowledge that the waters of Greaux contained bitumen was useful to him only because he knew from Galen that bitumen is hot and dry, and that hot and dry substances cure cold and wet ailments such as open wounds.[liii] Like all good Paracelsians, Rochas quoted few authorities and stressed the primacy of experience, "the "touchstone" and "sole light" of all the sciences.[liv] He cited no authorities, for example, in his account of the medical virtues of the sulphur that he used in his artificial waters. Instead he gave a long list of sulphurous springs and lakes in France that (he said) had a history of curing a wide range of diseases. Rochas also used case histories involving *artificial* waters to argue for the efficacy of those waters against sceptical Galenists.[lv] Clinical experience mattered at least as much to this avid Paracelsian as it did to physicians of a more traditional temper.

Givre also appealed to clinical experience—he knew that "examples often have more force than words"[lvi]—but his main evidence for the benefits of the Provins spring lay in their composition. He taught that "no-one can prescribe a mineral water correctly who cannot identify the minerals that imprint the water with their force and virtue." To identify those minerals merely by "the effects they produce on bodies" was to "expose the life and health of patients to sheer chance."[lvii] Givre argued that the Provins water contained iron and alum, that it contained eight times more iron than alum, and that it contained no vitriol. All of these conclusions were medically significant, or so Givre claimed. Iron and alum were the two

substances that Givre found in Spa water, implying that the waters of Provins were at least as salubrious as those of the famous German spring. The surplus of iron in Provins water tempered the astringency of its alum, allowing Givre to argue that Provins water was even more salubrious than Spa water. Finally, the absence of vitriol in Provins water meant that patients had no reason to stay away from Provins during the summer months, since there was no danger of the hot vitriol combining with the hot weather to overheat the sick body.[lviii]

Givre's claims about the composition of the Provins water were based on a substantial body of chemical theory and technique. His starting-point was the five-element-principle theory of the chemical teacher Estienne de Clave, whose *Cours de chimie* (1626) he cited.[lix] According to this theory, all substances are composed of five principles: mercury, sulphur, salt, earth, and phlegm. These principles are fundamental in the sense that each is incorruptible and none can be converted into any of the others.[lx] Applied to mineral waters, the theory implied that each component of a mineral water contains each of the five principles. For example, the waters of Provins contain the mercury principle of alum and the mercury principle of iron; the sulphur principle of alum and the sulphur principle of iron; and so on.[lxi] Crucially, the same principle takes different forms in different substances. This assumption enabled Givre to identify the components of mineral waters by isolating the principles of those components. For example, he believed that the earthy principle of alum is white and the earthy principle of vitriol is brown. He then found by experiment—that is, by a series of distillations, filtrations, and evaporations—that the earthy principle of Provins water is white. The assumption plus the experiment implied that the Provins water contains alum but not vitriol.[lxii] Givre corroborated these findings by performing the same experimental procedure on artificial mineral waters. He found, for example, that a solution of iron and water yields the same earths and salts as Provins water, whereas a solution of vitriol and water yields different earths and salts.[lxiii] Givre also made sophisticated use of the oak galls

test. He recorded the sequence of colour changes that Provins water underwent when mixed with oak galls, and he corroborated the result by observing the same colour changes in an artificial water made of iron and ordinary water.[lxiv]

Givre's search for the composition of mineral waters was not confined to laboratory operations. He climbed hills to find different kinds of earth and iron ore, collected samples of local minerals and stored them in his cabinet, ordered bottled water from Spa and three other springs to compare them to the Provins liquid, heated iron ores for hours on end, and spent three years waiting for the outcome of an experiment involving iron filings dissolved in vinegar.[lxv] Sometimes he had company: the visitors who admired his mineral collection; the local apothecary who tasted the results of his experiments; the "twenty to thirty *concitoyens*" who scrutinised the bubbles at the bottom of a corked phial of mineral water; the priest who reported that the spirits emanating from Provins water were abundant enough to punch holes in a sealed bottle.[lxvi] Givre did not exaggerate when he claimed to have "searched for the secret [of Provins water] with much effort and many experiments over the course of twelve years."[lxvii] The immediate goal of this search was to establish the identity of the waters' components—alum and iron but not vitriol. The ultimate goal was to use these identifications to show that only "an enemy of the public good" would deny the virtues of the Provins spa.[lxviii] In his evaluations of mineral waters, Givre married chemistry and medical practice. Chemists at the Paris Academy of Science did the same, from 1667 onwards.

4. Academic chemistry and medical practice (1667-1750)

The best summary of the Academy's programme of mineral water research is the one penned by Bernard le Bovier de Fontenelle, the Perpetual Secretary of the Academy and the first

editor of the Academy's annual *Histoire* and *Mémoires*. Fontenelle wrote the following in 1713:

> One of the first projects of the nascent Academy was to examine, in Paris, the kingdom's principal mineral waters. Duclos obtained most of them, and published a treatise on them. These waters are medical potions that emerge fully prepared from the depths of the earth, and although their virtues were first discovered by experience, it would be very advantageous to know them by reason as well, whether this is to make surer use of them, or to extend them to new ailments, or even to imitate by art these remedies lent to us by nature, and thereby preserve the ill from long, painful and often dangerous voyages. With these goals in mind we have studied with great care the minerals that enter into the composition of these waters, and the proportions of these components.[lxix]

Here Fontenelle tells us that the main aim of the Academy's programme was not to study mineral waters in their own right but to enhance their medical value, and that clinical "experience" mattered at least as much as chemical "reason" in the evaluation of the waters. The academicians who worked on mineral waters between 1667 and 1750 never lost sight of these two goals.

Let us briefly review the research in question, which is striking for its extent and continuity.[lxx] Between 1667 and 1674, Samuel Duclos and Claude Bourdelin analysed 90 waters that they had procured from 68 locations around France. These analyses were published in 1675 as *Observations sur les eaux minerales de plusieurs provinces de France*, a work that was still a leading authority nearly a century later.[lxxi] The academicians never again produced a work on mineral waters as comprehensive as this one, but they refined Duclos'

method of analysis and applied it to new sources. After a slow-down between 1676 and 1699[lxxii], the Academy's chemists produced a flurry of analyses, without much change in their analytic method, at the turn of the century.[lxxiii] These analyses gave way to a series of increasingly sophisticated studies of particular springs that were published in the Academy's *Mémoires* in the 1720s and 1730s.[lxxiv] More articles followed in the 1740s[lxxv], and at the end of the decade Louis-Guillaume le Monnier applied the improved procedures to a considerable number of mineral waters from around France, thereby reviving the spirit, if not the comprehensive scope, of Duclos' project.[lxxvi] To these major items, gleaned from the Academy's *Histoire* and *Mémoires*, we should add the following miscellany: four reports in the *Histoire* on the origins of the heat of mineral springs[lxxvii]; three books on materia medica that contained analyses done by academicians[lxxviii]; a proposal for a comprehensive survey of French mineral waters, written by Etienne-François Geoffroy but never implemented[lxxix]; and the copious notes on mineral waters that Jean Hellot recorded in his unpublished notebooks.[lxxx] Overall, 10 of the 20 chemists elected to the Academy between 1666 and 1750 carried out analyses of mineral waters that were published in one form or another. Of the remaining 10 chemists, two of them (Jean Grosse and Jean Hellot) had an interest in mineral waters that is obvious to a reader of Hellot's notebooks. With the curious exception of Wilhelm Homberg, the chemists who took no interest in mineral waters were minor figures compared to those who did.

Determining the medical efficacy of mineral waters was a major goal of most of these studies. This was true even for apothecaries such as Claude-Joseph Geoffroy and Gilles-François Boulduc, who said little about individual medical cases but who advised physicians on the best use of the waters they analysed. Geoffroy explained that the fineness of the iron in mineral waters makes it especially effective against chronic diseases; he thereby countered the "vulgar" opinion that mineral waters are a sham cure that physicians use to "rid

themselves of their patients when they no longer know what to do with them." Boulduc endorsed the English practice of taking ferrous mineral waters with milk. He also predicted that selenite would "revive the oscillations of enfeebled fibres and membranes" in patients who drank the waters of Passy.[lxxxi] He ended his three papers on mineral waters—those at Passy, Bourbon-l'Archambaud, and Forges—by summarising the medical effects of the waters in light of his new-found knowledge of their components.[lxxxii]

The physicians who studied mineral waters tended to supplement their analyses with lists of successful cases and general appeals to clinical experience, but they too were enthusiastic users of chemical knowledge. Claude Burlet argued for the systematic recording of successful and unsuccessful cases as a way of improving the "partial and traditional knowledge" that physicians possessed of mineral waters—but he also borrowed an instrument from Etienne-François Geoffroy to better measure the weight of the residue of Bourbon waters, and he argued vigorously for the preponderance of alkaline salt over marine salt in the waters of Bourbon.[lxxxiii] Louis-Guillaume le Monnier performed gruelling experiments on his own body in his examination of the waters of Barèges, waking at 4am on 20 consecutive mornings to weigh himself with great precision before and after his bath—yet he also complained of physicians who "tell tales of patients who have been cured by mineral waters, without troubling to discover the chemical principles that make them effective."[lxxxiv] Some physicians eschewed cases altogether. An example is Paul-Jacques Malouin, who knew that the analysis of mineral waters was "the hardest thing in chemistry" but continued his analyses undaunted, boldly proclaiming the existence of a new spirit and a new iron in the waters of Plombières.[lxxxv]

How much weight did chemical composition carry compared to clinical experience? This was a delicate question, and it is hard to find an academician whose answers were consistent with each-other and with the inferences he drew from his analyses. Some promised

a great deal from their analyses but gave few details about the illnesses their chosen water could cure. Some used their analyses to explain the known effects of a spring rather than to predict new effects.[lxxxvi] Other authors warned of the dangers of inferring effects from composition, but gave detailed accounts of the composition of a water nonetheless.[lxxxvii] Some hedged their bets, presenting a chemical analysis alongside an inventory of cases and leaving the reader to guess the connections between the two.[lxxxviii]

From these murky waters, two generalities emerge. Firstly, many academicians implied, and none denied, that chemical knowledge of the composition of mineral waters was an indispensable aid to physicians. We have seen that Fontenelle and several physicians at the Academy endorsed this view, and of course the apothecaries did too. Secondly, cases were at least as reliable as composition as a guide to the effects of a given water on the human body. This view is explicit in Monnier's papers and it is consistent with the writings of the apothecaries, who despite their enthusiasm for composition never claimed that it was *more* important than clinical experience. Even Boulduc conceded that the virtues of mineral waters were "known for the most part from the use and experience that medicine makes of them every day."[lxxxix] Most chemists at the Academy probably agreed with Fontenelle: "Once the nature of these waters is known, it is not impossible to predict the maladies they will cure, but experience is even more certain."[xc]

Whatever their justification, the views of academicians on the efficacy of this or that spring were not merely academic. We must remember that most of the chemists at the Academy—and nearly all of those who worked on mineral waters—were practising physicians or practising apothecaries, and that many of them held influential positions in their respective professions or in the courts of Louis XIV and Louis XV. Consider, firstly, the apothecaries. Claude Bourdelin ran a successful pharmaceutical business in Paris during his time as an academician; he also served as apothecary to a first cousin of Louis XIV and had a

reputation for dispensing sound medical advice along with his remedies.[xci] His was an extreme case, but not an atypical one. He had worthy successors in Gilles-François Boulduc and Claude-Joseph Geoffroy. Boulduc became apothecary to Louis XIV in 1712, and to the queen in 1736; Geoffroy took over his father's successful apothecary business in 1708 and was well regarded by other apothecaries, serving for a time as inspector of pharmacy at the Paris hospital, Hôtel-Dieu.[xcii] The physicians who studied mineral waters were no less influential. Duclos was a Médecin du Roi before he entered the Academy.[xciii] Etienne-François Geoffroy was "often consulted by other physicians" and served as the dean of the Paris Faculty of Medicine for an unusually long period in the 1720s.[xciv] Louis Lémery was a Médecin du Roi from 1722 onwards.[xcv] Chomel was equally at home at court and university, serving as a Médecin du Roi and as a professor at the Paris Faculty.[xcvi] Several of these individuals also taught botany or chemistry at the Jardin du Roi, where their audience included medical students. Two academicians (Tournefort and Monnier) had their analyses of mineral waters published in widely read books on materia medica. Etienne-François Geoffroy was especially influential. His views on the composition of mineral waters found their way into his chemistry lectures at the Collège Royal *and* into the Latin, English and French editions of his treatise on materia medica.[xcvii]

Geoffroy is also significant for the historical accident that a large cache of correspondence between he and his patients has survived in the library of the Paris Faculty of Medicine. These letters show not only that Geoffroy recommended mineral waters to his patients, but also that the composition of those waters was sometimes part of his recommendation. Consider the following advice, in a 1730 letter to a patient suffering from the stone: "The water of Sainte-Reine contains a subtle nitre that is ideal for dividing and tempering the blood, calming the heat of the kidneys [and] melting the phlegmy substances that accumulate in the kidneys."[xcviii] We have no comparable information about the

therapeutic practices of the other academicians who studied mineral waters. With one minor exception, they did not mention their own patients in their published papers.[xcix] However we may suppose that they put their opinions into practice, or at least that they did so as often as extra-academic physicians such as Jean Banc and Pierre le Givre.

Their opinions carried more weight when they represented higher powers such as the king, his ministers, or the Paris Faculty of Medicine. Jean-Baptiste Colbert ordered Bourdelin to examine the waters of Versailles in 1682. In 1737 the Premier médecin du Roi asked Claude-Joseph Geoffroy to examine a mineral water in the provinces that had attracted medical attention on the grounds that it contained nitre (Geoffroy concluded that it contained no such thing).[c] Louis Fagon—an Intendant des finances and Président of the Bureau du commerce—requested an appraisal of a spring from Grosse and Boulduc in 1735.[ci] These were one-off requests. For a more systematic relationship between academicians and the crown we may look towards Guy-Crescent Fagon, who dominated the medical life of Louis XIV's court as the Premier médecin du Roi between 1693 and 1715. Fagon was close to the Academy of Science and enthusiastic about the application of chemistry to the evaluation of mineral waters.[cii] Fagon's name does not occur in the flurry of reports on mineral waters that appeared in the Academy's *Histoire* around 1700, but it is plausible that he played a role in the revival of mineral water analyses at the Academy at that time.

Academicians were particularly influential in the emergence of Passy as a spa town in the eighteenth century. Between 1667 and 1724, academicians carried out at least four analyses of the various springs at Passy, then a town not far from Paris. Each of these analyses had implications for the prestige of the nascent spa. In 1667, Duclos and Bourdelin found much plastery matter in the one existing spring, and they concluded that the water had little medical value. According to Fontenelle, the spring went out of fashion as a result of this evaluation.[ciii] This changed when Louis Lémery examined the spring in 1701 and reported

that the plaster had vanished. Lémery had removed "the physical cause of [the spring's] discredit." A few years later, Fontenelle noted that Passy was once again popular among physicians and their patients.[civ] In 1719 three new springs were discovered on private property near the old spring. The Paris Faculty of Medicine commissioned Reneaume to examine the composition of all four springs. His positive appraisal of the new springs was one reason for the "*grande vogue*" that Passy enjoyed in the 1720s.[cv] The Academy intervened for a fourth time in 1724. Four more springs had been discovered, and the use of them caused the three discovered in 1719 to dry up. The owners of the springs clashed, and the case was referred to the Conseil des dépêches, a high-level council presided over by the Lieutenant-général de police. Claude-Joseph Geoffroy analysed the springs at the Conseil's request, and he reported that there was little difference between the best of the 1719 springs and the best of the newly discovered ones.[cvi] The Conseil des dépêches ruled that the new springs were unlawful and that no further wells would be dug at Passy, for fear of spoiling the existing ones.[cvii] Geoffroy did not say how his analyses affected this ruling, and there is no positive evidence that they did have an effect. But it is significant that one of the highest judicial bodies in France felt obliged to commission a chemical analysis of the water under dispute. Passy went on to become a French equivalent to England's Bath: a site of gardens and games rooms and balls and concerts, a setting for ballets and comic operas, and a subject of further disputes over the relative merits of the different springs, disputes that continued to be conducted in the language of academic chemistry.[cviii]

Medical practice supplied not only the motive for chemical analyses of mineral waters, but also the occasion and the raw materials. Régis went to Balaruc in 1699 because he was sick: "not content to use [the waters] like an ordinary patient, he studied them as a philosopher."[cix] Both Louis Lémery and Charles Dufay came to study mineral waters when their fathers fell ill and spent time bathing and drinking at Bourbonne-les-Bains.[cx] Sauveur-

François Morand travelled to Saint-Amand with the royal household, in his capacity as chief surgeon of the French Guards.[cxi] In addition, the analysts in Paris made use of bottled water that was sent to the capital to cure patients there. In 1671 a French surgeon by the name of Filesac was granted the right to transport bottled water from four French springs to Paris. Duclos and Bourdelin analysed water from these four springs in 1670 or 1671, and they may have availed themselves of Filesac's services.[cxii] A few years later, Bourdelin analysed bottles of water from Spa that had been sent to Paris to cure the wife of Louis XIV.[cxiii] In the 1720s and 1730s, as analyses became more sophisticated, they required ever greater quantities of starting material. For instance, Gilles-François Boulduc required 800 litres of Forges water to extract a sufficient quantity of Glauber's salt (24 grains) to identify that salt by its crystal form.[cxiv] This analysis would have been impossible without the ill health of the queen. The queen's physician, also a member of the Academy, advised her to undertake a course of bottled water; Boulduc arranged for the transport of this water from Forges to Paris, and he examined each day's consignment when it arrived in Paris.[cxv] Two years earlier, Boulduc had benefited from the generosity of Louis-Henri, Duke of Bourbon, who transported 100 bottles of water from Bourbon l'Archambault after undergoing a successful treatment there. Boulduc's analyses were nourished by the medical practice they were designed to improve.

The Academy's research on mineral waters was also nourished by the writings of physicians who did not belong to the Academy. In 1667, the year in which Duclos and Bourdelin began their analyses of mineral waters, Duclos wrote a review of Givre's *Secrets des eaux minerales de Provins.*[cxvi] Duclos criticised Givre's analytical procedure, and especially his practice of identifying earths and salts by their colour alone. This criticism should not obscure the fact that Duclos was satisfied with the arguments that Givre had given for his important claims that the waters of Provins contain iron, that they do not contain vitriol, and that subterranean iron is soft. In the eighteenth century, Burlet and Boulduc

discussed a treatise by J. Pascal in their papers on the Bourbon springs; Burlet engaged with Pierre Seignette's findings about the contents of those same springs; and Dufay's paper on the causes of the heat of mineral springs was a response to dissertations produced by students in the medical faculties of Troyes and Besançon.[cxvii]

As these citations suggest, physicians outside the Academy continued to perform chemical analyses of mineral waters after 1667. It is true that some physicians in this period opposed chemical analyses in favour of sensible properties as a guide to composition, and that some rejected composition altogether as a guide to the medical virtues of waters. It is also true that these conservatives were not members of the Academy of Sciences. However such individuals were few and far between. Of the 26 extra-academic methods of analysis that were published in France between 1667 and 1780, and that Carrère listed in his bibliography, only one rejected chemistry as a guide to composition and only one rejected composition as a guide to efficacy.[cxviii] In the closing decades of the seventeenth century, extra-academic analyses flourished under Guy-Crescent Fagon, who supported at least four major studies of mineral waters.[cxix] Two of these studies, by Claude Fouet and J. Pascal, are notable for their precocious use of the Helmontian theory that diseases are best understood in terms of the relationship between acidic and alkaline substances in the body.[cxx] Fagon plainly believed that chemical analyses mattered for medicine. As he put it in 1686, knowledge of the "principles" of mineral waters is useful, not just to "better know" the waters in question, but also "to apply them more judiciously" in curing diseases.[cxxi]

Extra-academic analyses continued in the eighteenth century. Three influential analysts emerged from the Montpellier Faculty of Medicine, where chemical analyses of mineral waters had part of the curriculum from at least 1673.[cxxii] Gabriel-François Venel studied the waters of Passy in 1755, and in the same year he was instructed by royal ordonnance to carry out a systematic chemical study of French springs.[cxxiii] Théophile

Bordeu, Intendant of the mineral waters of Aquitane, published vast compilations of case histories on these waters in the 1740s, and he praised the chemical studies of Venel and his collaborator, the pharmacist Pierre Bayen.[cxxiv] The third example is Charles le Roy, an esteemed professor and practitioner at Montpellier whose review of the chemical composition of French mineral waters appeared in Latin in 1758, in the *Encyclopédie* of Diderot and d'Alembert in 1765, and in five other publications up to 1772.[cxxv] It must be admitted that chemical analyses of mineral waters became more systematic in the 1770s, with the advent of the Commission Royale de médecine (1772) and the Société Royale de médecine (1778).[cxxvi] But the 1770s marked a change of degree, not of kind.

Conclusion

I have been arguing for two conclusions, one fixed and the other open-ended. The fixed conclusion is that academic chemists and physicians outside the Academy shared an interest in using the composition of mineral waters as a guide to their medical efficacy. Granted, scepticism about this procedure was more likely to come from outside the Academy than from inside. However physicians were willing to appeal to composition from as early as 1603, when Jean Banc published his treatise on the waters of Pougues. A century later, chemists such as Etienne-François Geoffroy and Gilles-François Boulduc were eager to bring their chemical discoveries to bear upon therapeutics, and their advice had considerable influence. The practice of evaluating mineral waters by studying their composition did not fall between the two stools of chemistry and medicine. Instead it was a crucial consideration for many students of mineral waters in France in the seventeenth and eighteenth centuries.

The open-ended conclusion is that iatrochemistry played a complex role in these

evaluations. There is no doubt that followers of Paracelsus and van Helmont were among the earliest and most enthusiastic French proponents of thorough-going chemical analyses of mineral waters. Henry de Rochas and Pierre le Givre were notable Paracelsians, the former a precocious outsider to the medical establishment and the latter an advanced insider. Claude Fouet's treatise of 1686 may be called Helmontian insofar as it was based on the acid/alkali theory of disease. A decade later, Linand and Larouvière used the same theory in their analyses of the waters of Forges and Bourbon-l'Archambault. This narrative of the advance of iatrochemistry must be qualified in four ways, however. Firstly, evaluation by composition preceded evaluation by chemistry. Jean Banc's ignorance of oak galls and fractional distillation did not prevent him from judging mineral waters on the basis of their smell, taste, and texture. Secondly, Paracelsians and Helmontians did not have a monopoly on chemical techniques. Traditional physicians such as Jean Aubery and Isaac Cattier were familiar with distillation and evaporation, and they were willing to use it when it suited their purposes, despite their reservations about *les Paracelsistes* and *la médecine spagyrique*. Thirdly, the advance of chemistry did not always mean the advance of chemical *evaluations* of mineral waters. For Rochas, chemistry was unnecessary in the evaluation of artificial waters, and insufficient in the evaluation of both natural and artificial waters. Finally, the advance of chemical evaluations did not displace case histories as a guide to the efficacy of mineral waters. Fontenelle and Gilles-François Boulduc were staunch defenders of the utility of chemistry, but both of them admitted that clinical experience was at least as important as laboratory experiments in the final assessment of any given spring.

Clearly there is more to say about the evaluation of mineral waters in early modern Europe. I have focused on one constant in those evaluations (composition), one major change (the adoption of chemical analyses), and one major cause of that change (iatrochemistry). A full study would need to consider changing attitudes to artificial waters, and changing

theories about the geology and physiology of mineral waters. All of these changes affected the *kind of evidence* that were invoked in favour of this or that spring. But there were also changes in what we might call the *mode of accreditation* of mineral waters. By the latter I mean the cluster of laws, texts, institutions and authorities that brought the evidence to the attention of patients and physicians. The mode of accreditation could lend extra weight to the evidence. In the case of Passy, for example, we can discern a hierarchy of credit running upwards from the analysis published in the dissertation of a student at the Paris Faculty, to the one performed by Louis Lémery and reported in the Academy's *Histoire* for 1701, to the one that Claude-Joseph Geoffroy submitted to the Conseil des dépêches and reported in the Academy's *Mémoires* in 1724. The mode of accreditation may also have affected the *kind* of evaluation performed. It was not uncommon in the seventeenth century for members of a medical faculty, usually Paris or Montpellier, to make a brief visit to a spring and deliver a judgement on its medical virtues.[cxxvii] In such cases, the physicians had little choice but to base their pronouncement on the composition of the spring. A short visit to a spring was sufficient to taste and smell the spring, but not sufficient to accumulate a long list of first-hand case histories. The history of the evaluation of mineral waters—or for that matter the evaluation of metals, dyes, porcelain, or precious stones—is a history of credit as well as evidence.

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[i] From a poem in Jean Aubery, *Les bains de Bourbon-Lancy et L'Archambaut* (Paris, 1605). All translations in this article are my own unless otherwise stated.

[ii] Gilles-François Boulduc, "Analyse des eaux de Forges, et principalement de la source appellée la Royale", *Hist. Acad. Roy. Sci.* (1735): 443-52, on 443.

[iiiiii] The literature on early modern European spas is large but diffuse. Useful older histories include Hector Grasset, *La médecine naturiste à travers les siècles* (Paris: Rousset, 1911);

and William Addison, *English Spas* (London: Batsford, 1951). The most recent *mise au point* is *Med. Hist. Sup.* no. 10 (1990).

iv On colour indicators see Allen Debus, "Solution Analyses Prior to Robert Boyle", *Chymia* 8 (1962): 41–61. On salts see Frederic L. Holmes, *Eighteenth-Century Chemistry as an Investigative Enterprise* (Berkeley: Office for History of Science and Technology, 1989), 43 and Mi Gyung Kim, *Affinity, That Elusive Dream: A Genealogy of the Chemical Revolution* (Cambridge, MA: MIT Press, 2003), 154-55. On airs see Jon Eklund, "Chemical Analysis and the Phlogiston Theory, 1738-1772: Prelude to Revolution" (PhD dissertation: Yale University, 1971), chap. 7; idem, "Of a Spirit in the Water: Some Early Ideas on the Aerial Dimension," *Isis* 67, no. 4 (1976): 527–50. On water and earth see Bernadette Bensaude-Vincent, "Eaux et mesures: éclairages sur l'itinéraire intellectuel du jeune Lavoisier," *Rev. hist. sci.* 48 (1995): 49–69, on 67.

[v] Noel Coley, "'Cures Without Care': 'Chemical Physicians' and Mineral Waters in 17th Century English Medicine", *Med. Hist.* 23 (1979): 191–214, on 210-12; and idem, "The Preparation and Uses of Artificial Mineral Waters (ca. 1680-1825)", *Ambix* 31 (1984): 32–48.

vi Laurence Brockliss, "The Development of the Spa in Seventeenth-century France," *Med. Hist.* (1990): 23-47, quotation on 41.

[vii] On early modern iatrochemistry, see especially Hélène Metzger, *Les doctrines chimiques en France du début du XVIIe siècle à la fin du XVIIIe siècle* (Paris: Albert Blanchard, 1969), esp. chap. 3; Allen Debus, *The Chemical Philosophy: Paracelsian Science and Medicine in the Sixteenth and Seventeenth Centuries*, 2 vols (New York: Science History Publications, 1977; idem, *The French Paracelsians: The Chemical Challenge to Medical and Scientific Tradition in Early Modern France* (Cambridge University Press, 2002).

[viii] Debus, "Solution Analysis". Cf. Debus, *Chemical Philosophy*, 14-19, 109-12, 347-57.

[ix] Brockliss, "Development of the Spa", 23-4; Coley, "Cures Without Care", 194.

[x] Christopher Hamlin, "Chemistry, Medicine, and the Legitimization of English Spas, 1740-1840", *Med. Hist. Supp.* 10 (1990): 67–81, on 69.

[xi] Ibid., 70-1.

[xii] Coley, "Cures Without Care", 199-204, cf. Debus, *Chemical Philosophy*, vol. 2, 497.

[xiii] Coley, "Cures Without Care", 199, cf. 204 n. 52.

[xiv] See the list beginning on Joseph-Barthélemy-François Carrère, *Catalogue raisonné des ouvrages qui ont été publiés sur les eaux minérales en général et sur celles de la France en particulier* (Paris, 1785), 82 (including the texts mentioned in the footnote).

[xv] See the lists beginning on ibid. pp. 391, 161, 177, 164, 373, 194. The springs are Forges, Bourbon-L'Archambault, Bourbon-Lancy, Vichy, Pougues, and Provins.

[xvi] The treatise was republished in 1618 under the title *Admirables vertus des eaux naturelles de Pougues, & autres renommées de France*: Carrère, *Catalogue raisonné*, 376. I have used the 1618 edition.

xvii Banc, *Eaux naturelles de Pougues*, Privilège du Roi (degree), 130 (practice).

[xviii] Ibid., 36-38. The other author was the academician Samuel Duclos.

[xix] "Essai d'analyse en général des eaux minérales chaudes de Bourbon- L'Archambaud," *Mem. Ac. Roy. Sci.* (1729): 258-76, on 258-9.

[xx] Cf. Carrère, *Catalogue raisonné*, 37.

xxi Ibid., 129, 133-34, 136, 94-95.

xxii Ibid., 18-23, cf. 47, 129.

xxiii Ibid., 101, 108.

xxiv He invoked them less often for cold waters, but this is because he believed that all cold waters contain the same three minerals, namely iron, bitumen, and vitriol: ibid, 18-22, 72.

xxv Ibid., 75-77, 33, 74.

xxvi Ibid., 81-83.

xxvii Ibid., 112, cf. 91-92, 131-32.

xxviii Jean Aubery, *Les bains de Bourbon-Lancy et l'Archanbaut* (Paris, 1604).

xxix Carrère, *Catalogue raisonné*, 13, 161. Compare Aubery, *Bains de Bourbon*, 107r-131r, with Jean de Combe, *Hydrologie, ou discours des eaux* (Aix, 1645), 180-239.

xxx This term appears at Aubery, *Bains de Bourbon*, 119v, and Combe, *Hydrologie*, 214.

xxxi William Newman, "From Alchemy to 'Chymistry'", in *The Cambridge History of Science, volume 3: Early Modern Science* (Cambridge: Cambridge University Press, 2006), ed. Lorraine Daston and Katharine Park, pp. 497-517, on 409.

xxxii Combe refers to "*Paracelsistes*", Aubery to "*la secte de Paracelse*." Combe, *Hydrologie*, 202; Aubery, *Bains de Bourbon*, 113r.

xxxiii Aubery, *Bains de Bourbon*, 113r, 116r, 119r-120v; cf. Combe, *Hydrologie*, 202, 192-3, 213-5.

xxxiv Aubery, *Bains de Bourbon*, 115r-116r, cf. Combe, *Hydrologie*, 183-5.

xxxv Aubery, *Bains de Bourbon*, 119v-131r, cf. Combe, *Hydrologie*, 213-39.

xxxvi *De la nature des bains de Bourbon* (Paris, 1650).

xxxvii Cattier, *Bains de Bourbon*, 82-4.

xxxviii Pierre le Givre, *Le secret des eaux minerales acides* (Paris, 1667), 229-30.

xxxix Pierre le Givre, *Traité des eaux minerales de Provins* (Paris, 1653), 114-17, 127-28; idem, *Eaux minerales acides*, 43-46.

xl Givre, *Eaux minerales de Provins*, 126-27; idem, *Eaux minerales acides*, 222, 224, 244-48, 288-90.

xli Givre, *Eaux minerales de Provins*, 13; idem, *Eaux minerales acides*, 41-3, 237-42, 288-90.

[xlii] *Traité des observations nouvelles et vrayes cognoissances des eaux minerales* (Paris, 1734). I have used the second edition, which is an enlarged version of the first: *La vraye anatomie spagyrique des eaux mineralles* (Paris, 1736).

[xliii] Debus, *French Paracelsians*, chap. 3.

[xliv] Rochas, *Anatomie spagyrique*, book 1, 5-56, 79-83, esp. 5 (spagyric medicine), 79-80 (sulphur), 64-8, 78-9 and 107-8 (artificial waters), and 241-302 (universal spirit); book 2, 13-25 (principles), and 165-80, esp 168 and 178 (on Galenists and spagyria). Cf. Debus, *French Paracelsians*, 76.

[xlv] Debus, *French Paracelsians*, 95-9.

[xlvi] Respectively, *Traité des eaux minerales de Provins*, and *Le secret des eaux minerales acides*. I have used the second (1659) edition of the former work. A Latin edition of the latter work was published in Amsterdam in 1682 as *Arcanum Acidularum*.

xlvii Givre, *Eaux minerales acides*, 5, 7.

[xlviii] See the dedications in Givre's *Traité des eaux minerales de Provins* (Paris, 1659) and his *Le secret des eaux minerales acides* (Paris, 1677), as well as the Approbation in the former treatise.

[xlix] Pierre Givre, *Traité des eaux minerales de Provins* (Paris, 1659), 36-9, cf. Pierre Givre, *Le secret des eaux minerales acides* (Paris, 1677), 34.

l Givre, *Eaux minerales acides*, 64, 122. Provins is located some 80km south-east of Paris.

[li] On the renovation see Givre, *Eaux minerales de Provins*, 91, 370; *Eaux minerales acides*, 366-7.

[lii] Givre, *Eaux minerales de Provins*, 94, cf. "Avis au lecteur", and *Eaux minerales acides*, "Avis au lecteur," 370.

[liii] Combe, *Hydrologie*, 232, cf. 219-23 (sulphur) and 236-7 (nitre).

[liv] Rochas, *Anatomie spagyrique*, book 1, 1-2.

[lv] Rochas, *Anatomie spagyrique*, 73-9, 173, 179, cf. the long list of case histories at the end of the treatise, 60-135.

[lvi] Givre, *Eaux minerales de Provins*, 62.

lvii Givre, *Eaux minerales acides*, 4, 277. Givre even applied this principle to his own illnesses: *Eaux minerales de Provins*, 88-9.

[lviii] On vitriol see Givre, *Eaux minerales de Provins*, "Avis au lecteur", 30-35; *Eaux minerales acides*, 61-7. On iron and alum see Givre, *Eaux minerales acides*, "Avis au lecteur."

[lix] Estienne de Clave stated the theory at *Cours de chimie* (Paris, 1626), 4-5 and 22-4. Compare the recipe on p. 141 of Clave's treatise with the one at Givre, *Eaux minerales acides*, 44.

lx Givre, *Eaux minerales de Provins*, 5.

lxi Ibid., 39-42.

lxii Givre, *Eaux minerales acides*, 11-14.

lxiii Ibid., 24-25, 53-55.

lxiv Ibid., 5-9, 27-28, 279-80, cf. 215.

lxv Givre, *Eaux minerales de Provins*, 2-3, cf. *Eaux minerales acides*, 114-16 (climbing); *Eaux minerales de Provins*, 124, cf. *Eaux minerales acides*, 219 (cabinet); *Eaux minerales acides*, 99, 104, 122 (bottled water); *Eaux minerales de Provins*, 4 (heating); *Eaux minerales de Provins*, 12, cf. *Eaux minerales acides*, 54 (iron filings).

lxvi Givre, *Eaux minerales de Provins*, 124 (collection), 10 and 123 (apothecary), 9 (concitoyens), 11 (priest).

lxvii Givre, *Eaux minerales acides*, Dedication.

[lxviii] Ibid., 69.

lxix Fontenelle, "Sur plusieurs eaux minerales de France", *Hist. Ac. Roy. Sci.* (1713): 57-61, on 57.

[lxx] This survey expands on the limited data in Eklund, "Prelude to Revolution," 232, 281-83, and on the scattered data in Grasset, *Médecine naturiste,* chaps. 11 and 12. More is known about French studies in the second half of the eighteenth century, which is why I stop in 1750: Eklund, "Prelude to Revolution", 284-8; Bensaude-Vincent, "Eaux et mesures"; Coley, 39-42. My survey is based mainly on the items listed under "*eaux minerales*" in Pierre Demours, *Table générale des matières contenues dans l'*Histoire *et dans les* Mémoires *de l'Académie royale des sciences*, vols. 1-6 (1729-1758).

[lxxi] Fontenelle, "Analise de plusieurs eaux minerales", *Hist. Ac. Roy. Sci. 1666-1669* (1733), vol. 1, 27-35, 123-4. Duclos, *Observations sur les eaux minerales de plusieurs provinces de France.* This text was published separately in 1675, and as a supplement to the Academy's *Mémoires* of 1731. I have used the supplement. On Duclos as an authority, see Carrère, *Catalogue raisonnée*, 98 and *passim*; and the references to Duclos at, eg. *Hist. Ac. Roy. Sci.* (1701): 63, (1702): 44, (1713): 29-30, and Paul-Jacques Malouin, "Analyse des eaux savonneuses de plombières," *Mém. Ac. Roy. Sci.* (1746): 109-28, on 109.

[lxxii] A slow-down, but not a halt: experiments from 1678, 1682, and 1696, are reported respectively at *Hist. Ac. Roy. Soc.* (1703), 18; (1708), 59; and (1733 [1683]), 367-69, 373.

[lxxiii] *Hist. Ac. Roy. Soc.* (1699): 55-57, (1700): 58-60, 101-110, (1701): 62-66, (1702): 42-46, (1705): 66-68, (1706): 40-41, (1708): 59-61, (1712): 20-23, (1712): 29-30. See also Claude Burlet, "Examen des eaux de Vichi et de Bourbon," *Mem. Ac. Roy. Sci.* (1707): 97-104; Claude Burlet, "Examen des eaux de Bourbon," *Mem. Ac. Roy. Sci.* (1707): 112-20.

lxxiv Claude-Joseph Geoffroy, "Nouvel examen des eaux de Passy," *Mem. Ac. Roy. Sci.,* (1724): 193-208. Gilles-François Boulduc's papers were "Essai d'analyse en général des nouvelles eaux minérales de Passy," *Mem. Ac. Roy. Sci.,* (1726): 306-327; "Analyse des eaux de Bourbon-L'Archambault"; "Analyse des Eaux de Forges, et principalement de la source appellée la Royale," *Mem. Ac. Roy. Sci.* (1729): 443-452. Cf. the reports by Michel-Louis

Reneaume and Claude-Joseph Geoffroy: *Hist. Ac. Roy. Sci.* (1720): 42-46, (1737): 63-64.

lxxv Sauveur-François Morand, "Sur les eaux minérales de Saint-Amand en Flandre," *Mém. Ac. Roy. Sci.* (1743): 1-16. Malouin, "Eaux savonneuses de plombières."

lxxvi Monnier, "Observations d'histoire naturelle faites dans les provinces méridionales de la France pendant l'année 1739," *Mem. Ac. Roy. Soc* (1740 supplement): cix-ccxxxv, on clxxvii-cxcii, ccxix-ccxxii. Idem, "Examen des eaux minérales du Mont d'Or," *Mém. Ac. Roy. Soc.* (1744): 157-69. Idem, "Examen des quelques fontaines minerales de la France, & particulièrement de celles de Baredge," *Mém. Ac. Roy. Soc.* (1747): 259-271, especially 259 where he announced the France-wide analyses later published in Moyse Charas, *Pharmacopée royale galénique et chimique*, new edition (1753).

lxxvii The authors were Moyse Charas, Nicolas Lémery, Charles Dufay, and an unnamed provincial physician. See respectively: *Hist. Ac. Roy. Sci.* (1692): 183-87, (1693): 288-90; Nicolas Lémery, "Explication physique et chimique des feux souterrains, des temblemens de terre, des ouragans, des éclairs & du tonnerre," *Mém. Ac. Roy. Soc.* (1700): 101-10; *Hist. Ac. Roy. Sci.* (1724): 47-50 and Procès-verbaux de l'Académie Royale des sciences, 8 Apr. 1724, 153v-157v; *Hist. Ac. Roy. Sci.* (1730): 52-54.

lxxviii Joseph Pitton de Tournefort, *Materia Medica, with an Appendix Shewing the Nature and Use of Mineral Waters* (1708). Moyse Charas, *Pharmacopée royale galénique et chimique*, new edition (1753), containing analyses by Monnier. Etienne-François Geoffroy, *A Treatise of the Fossil, Vegetable, and Animal Substances, that are Made Use of in Physick*, trans. G. Douglas (London, 1736), vol. 1, 47-54; idem, *Tractatus de materia medica* (Paris, 1741), vol. 1, 55-65; idem, *Traité de la matière medicale*, trans. A. Bergier (Paris, 1743), vol. 1, 91-107. The titlepage of the 1736 work describes it as a translation from a manuscript copy of Geoffroy's Collège Royal lectures. Cf. Smeaton, "Geoffroy, Etienne-François", 354.

lxxix Christiane Demeulenaere-Douyère and David Sturdy, *L'Enquête du Régent, 1716–1718:*

sciences, techniques, et politique dans la France pré-industrielle (Turnhout: Brepols, 2008), 81-83.

lxxx Hellot notebooks, Bibliothèque municipale de Caen, vol. 8, 74v-75v, 79r-v, 84r-85r, 89r-93r, 214v-226r, 239r-239b.

lxxxi C.-J. Geoffroy, "Nouvel examen des eaux de Passy," 204; Boulduc, "Nouvelles eaux de Passy," 322, 327.

lxxxii Boulduc, "Nouvelles eaux de Passy," 327; idem, "Minérales chaudes de Bourbon-l'Archambaud," 260, cf. 276; idem, "Analyse des Eaux de Forges," 452.

lxxxiii Burlet, "Examen des eaux de Bourbon," 115-16; idem, "Examen des eaux de Vichi et de Bourbon," 99, 104.

lxxxiv Monnier, "Fontaines minerales de Baredge," 259-60, 270.

lxxxv Malouin, "Eaux savonneuses de Plombières," 109-10.

lxxxvi Eg. Geoffroy, "Nouvel examen des eaux de Passy," 208; Malouin, "Eaux savonneuses de Plombières," 128.

lxxxvii Eg. Monnier, "Observations d'histoire naturelle," clxxxviii; idem, "Eaux minérales du Mont d'Or," 165.

lxxxviii Eg. Morand, "Eaux minérales de Saint-Amand."

lxxxix Boulduc, "Analyse des eaux de Bourbon-l'Archambaud," 276. Cf. idem, "Nouvelles eaux minerales de Passy," 327, and the ambiguous statement on 308.

xc *Hist. Ac. Roy. Soc.* (1700): 64. Cf. Fontenelle's remarks at *Hist. Ac. Roy. Soc.* 1 (1733 [1683]): 369, (1726): 34.

xci Dorveaux, "Les grands pharmaciens: Apothicaires membres de l'Académie royale des sciences," *Bull. Soc. Hist. Pharm* 17, no. 64 (1929): 289-298, on 290-3.

xcii Dorveaux, "Apothicaires membres de l'Académie Royale des Sciences: IV. Gilles-François Boulduc; V. Etienne-François Geoffroy," *Bull. Soc. Hist. Pharm* 19, no. 74 (1931):

113-26, on 113-6. W. A. Smeaton, "Geoffroy, Claude Joseph," in *Dictionary of Scientific Biography*, ed. Gillispie, vol. 5, 351-2, on 351.

xciii Sturdy, *Science and Social Status*, 108.

xciv W. A. Smeaton, "Geoffroy, Etienne-François," in *Dictionary of Scientific Biography*, ed. Gillispie, vol. 5, 352-4, on 352.

xcv Owen Hannaway, "Lémery, Louis," *Dictionary of Scientific Biography*, ed. Gillispie, vol. 8, 171-2, on 171.

xcvi David Sturdy, "Pierre-Jean-Baptiste Chomel (1671-1740): A Case Study in Problems Relating to the Social Status of Scientists in the Early Modern Period," *Brit. Journ. Hist. Sci.* 19, no. 3 (1986): 301-322, on 307.

xcvii See note 78 above.

xcviii Quoted in Laurence Brockliss, "Consultations by Letter in Early Eighteenth-Century Paris: The Medical Practice of Etienne-François Geoffroy", in *French Medical Culture in the Nineteenth Century*, ed. Ann La Berge and Mordechai Feingold (Amsterdam: Rodopi, 1994), 79–117, on 98.

xcix The exception is Reneaume, at *Hist. Ac. Roy. Soc.* (1720): 46.

c *Hist. Ac. Roy. Soc.* 1 (1733 [1683]): 367, (1737): 63.

ci Hellot notebooks, vol. 8, 214r.

cii On Fagon see Sturdy, *Science and Social Status*, 229-30; Brockliss, "Development of the Spa," 30; and the penultimate paragraph of this section.

ciii *Hist. Ac. Roy. Soc.* (1701): 62, 65. Cf. *Hist. Ac. Roy. Soc.* 1 (1733 [1667]): 29; Duclos, *Observations sur les eaux minérales*, 65.

civ *Hist. Ac. Roy. Soc* (1720): 42.

cv C.-J. Geoffroy, "Nouvel examen des eaux de Passy," 194.

cvi Ibid., 194. Cf. *Hist. Ac. Roy. Sci.* (1724): 50-54.

cvii Jacques Cornu, *Contribution à l'histoire de la pharmacie: Paris, station thermale* (Paris: A. Coueslant, 1952), 49.

cviii Ibid., 51-52, 54-58.

cix *Hist. Ac. Roy. Sci.* (1699): 55. Cf. *Hist. Ac. Roy. Sci.* (1708): 59.

cx *Hist. Ac. Roy. Sci* (1700): 59. Dufay to Réaumur, 31 May 1723, in *Correspondance historique et archaelogique* 5 (1898), 308; Dufay, "Eaux chaudes de Bourbonne"; Mathieu Marais, *Journal et mémoires...sur la régence et le règne de Louis XV* (Paris, 1864), vol 2, 490.

cxi Morand, "Eaux minérales de Saint-Amand," 3.

cxii Brockliss, "Development of the Spa", 40. Duclos, *Eaux minerales*, 33. Cf. Givre's use of bottled water from distant spas, *Eaux minerales acides*, 99, 104, 122.

cxiii Duclos, *Eaux minerales*, 79.

cxiv Boulduc, "Analyse des eaux de Forges," 451-52.

cxv Ibid., 444-5.

cxvi "Examen du livre des eaux minerales du sieur Givre", Procès-verbaux de l'Académie Royale des sciences, vol. 1, 57r-70r.

cxvii Burlet, "Examen des eaux de Bourbon," 115-8; Boulduc, "Analyse des eaux de Bourbon-l'Archambaud," 258-9; Dufay, "Eaux chaudes de Bourbonne", 154v-155r. The dissertations were Gautier, *Dissertation sur les eaux minérales de Bourbonne-les-bains* (Troyes, 1716); and Jean-Claude Callet, *An pluribus morbis chronicis Aquae thermales Borbonienses in Campanid Vesuntione* (Besançon, 1716).

cxviii These works were Jean-François Borie, *La recherché des eaux minerals de Cauterets* (Tarbes, 1714) and Hugone Gourraione, *Quaestiones medicae duodecim* (Montpellier, 1748). Carrère, *Catalogue raisonné*, 19, 23.

[cxix] Claude Fouet, *Nouveau sisteme des bains et eaux minerals de Vichy* (Paris, 1686), "Approbation" by Fagon. J. Pascal, *Traité des eaux de Bourbon l'Archambaud selon les principes de la nouvelle physique* (Paris, 1699), dedication to Fagon. J. Larouvière, *Nouveau système des eaux minérales de Forges* (Paris, 1699), Dedication to Fagon, and "Preface." Pierre Seignette, "Analises de plusieurs eaux minerales de france faites sur les lieux en 1696 et 1697," in Archives Departmentales de La Rochelle, Ms. 1 Mi art. 664 ("Manuscrit Famille Seignette, XVIIIe siècle"). Cf. Henriette Murat, "La gloire des Seignette," *Annales de l'Académie de La Rochelle* (1996-7): 47-62, esp. 55. Fagon may also have had a hand in Barthelemy Linand, *Nouveau traité des eaux minérales de Forges* (Paris, 1697).

[cxx] On the acid/alkali theory and its reception in France, see Debus, *French Paracelsians*, 115-9, 148, 153; Metzger, *Doctrines chimiques*, 199-219, esp. 204, 207.

[cxxi] Fouet, *Nouveau sisteme de Vichy*, "Approbation." Cf. similar sentiments in Fouet, *Nouveau sisteme de Vichy*, "Preface", and Larouvière, *Nouveau système de Forges*, Dedication to Fagon.

[cxxii] Sebastian Matte-le-Faveur, *Pratique de chymie, divisée en quatre parties, avec un avis sur les eaux minerales* (Montpellier, 1671), 355-60. Cf. Debus, *French Paracelsians*, 144-5.

[cxxiii] Venel, *Examen chimique d'une eau minérale nouvellement découverte à Passy* (Paris, 1755); W. A. Smeaton, "Venel, Gabriel-François", in *Dictionary of Scientific Biography*, ed. Gillispie, vol. 13, pp. 602-4, on 602, 603; Eklund, "Prelude to Revolution", 284-5.

[cxxiv] Grasset, *Médicine naturiste*, 333-7, esp. 335.

[cxxv] Carrère, *Catalogue raisonné*, 26-7; J. B. Gough, "Le Roy, Charles", in *Dictionary of Scientific Biography*, ed. Gillispie, vol. 8, pp. 255-6.

[cxxvi] Pascale Cosma-Muller, "Entre science et commerce: les eaux minérales en France à la fin de l'Ancien Régime", *Réflexions Historiques* 9, no. 1 (1982): 249–62.

[cxxvii]Banc, *Eaux naturelles de Pougues*, 92; Givre, *Eaux minerales de Provins*, "Approbation

des médecins"; Sturdy and Demeulenaeure-Douyère, *Enquête du Régent*, 287-8.